The upgraded LTP-V @ SLS

Uwe Flechsig

Paul Scherrer Institut, Villigen, Switzerland

IWXM Barcelona, July 2012

Outline

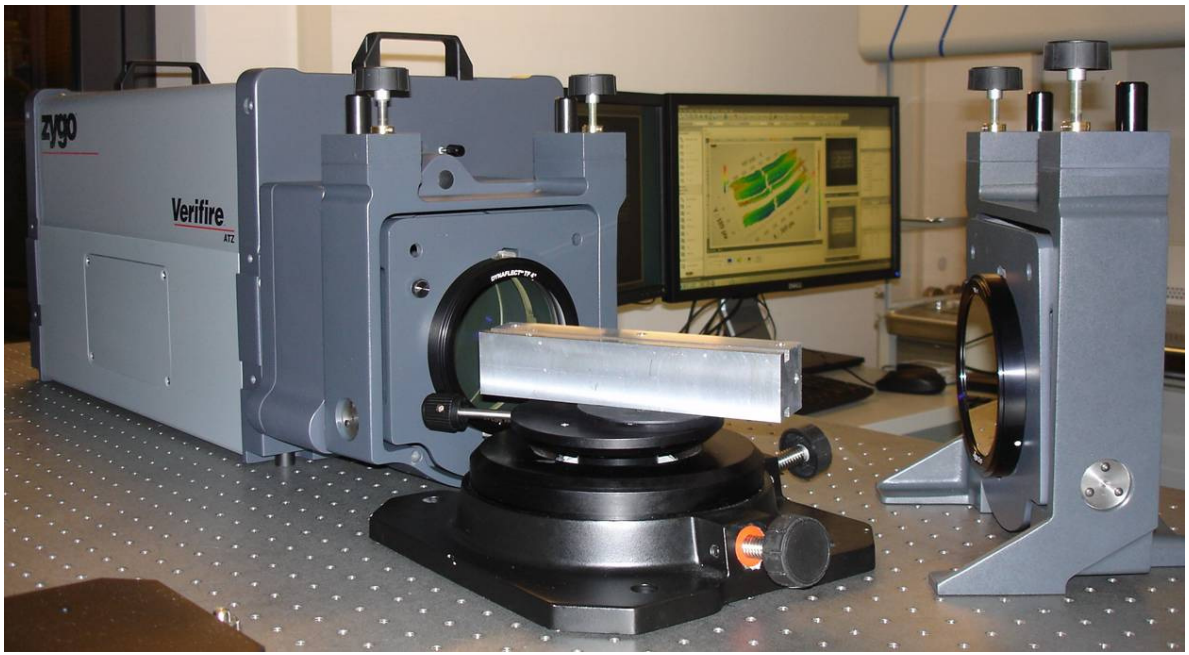
SLS Beamline Optics Group

- Uwe Flechsig, physicist (1998)
- Peter Oberta, physicist (2009-2011)
- Sibylle Spielmann, engineer (2007)
- Andreas Jaggi, technician (2005)
- Juraj Krempaský, controls expert (2010)
- Vincent Thominet, engineer (2011)

The metrology lab at SLS

- Mission:
  - quality assurance measurements of X-ray optics
  - figure (slope error) $\Delta s = 0.1\,\mu\mathrm{rad}$
  - roughness $\Delta h = 0.1\,\mathrm{nm}$
  - grating parameters (profile measurements with AFM)
  - scratches, digs etc., mechanical dimensions, radii, (grating efficiency)
- environment:
  - clean room class 10000 / 1000 (inside LTP shelter)
  - temperature stability < 0.1 K/ day, for comparison expansion coefficients of concrete and steel: $\alpha \approx 15\,\mu\mathrm{m K^{-1} m^{-1}}$
  - *low* mechanical vibrations and electromagnetic noise, (Gordon criteria: VC-D ... VC-E $\equiv 3\,\mu\mathrm{m/s/terz}$)

Fizeau Interferometer Zygo Verifire ATZ



grazing incidence setup

installed DEC 2011

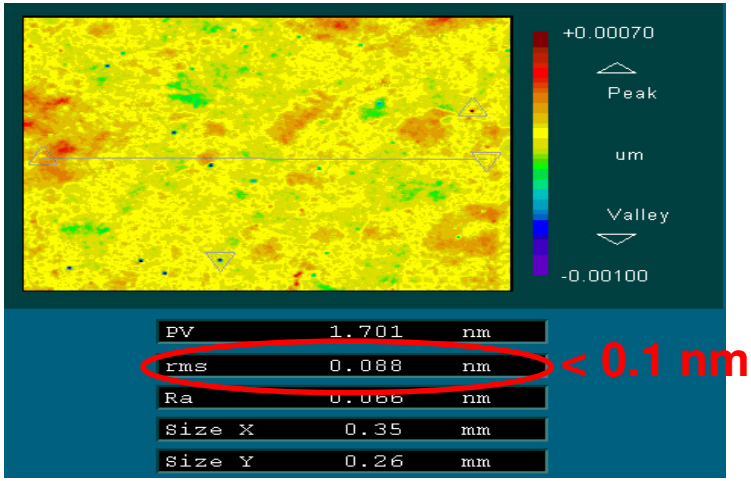
Features

- aperture: 100 mm
- camera: (1000×1000)*pixels*, frame rate: 43 Hz
- PV wavefront error $< \lambda/36$
- RMS wavefront repeatability 0.35 nm or $< \lambda/1800$

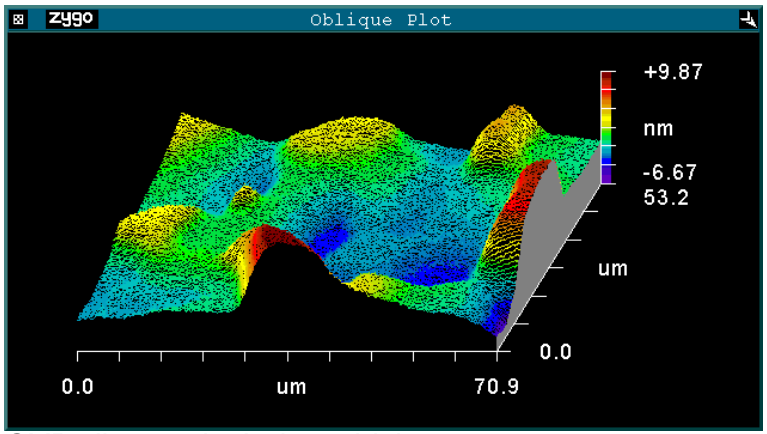
Interference microscope Zygo NewView 5010

microscope

installed 2001, DEC 2011
upgraded (motorized stage for stitching, new computer, software upgrade)

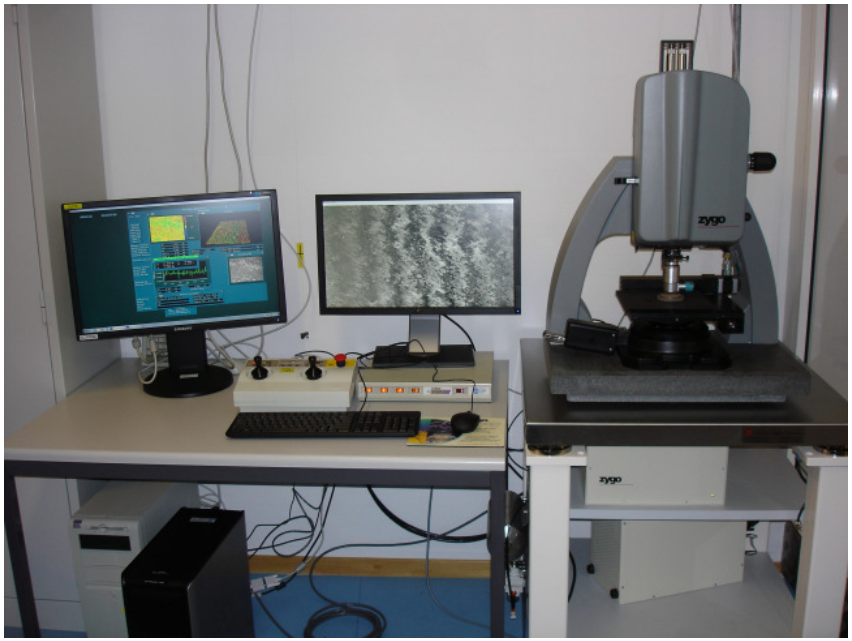


reproducibility



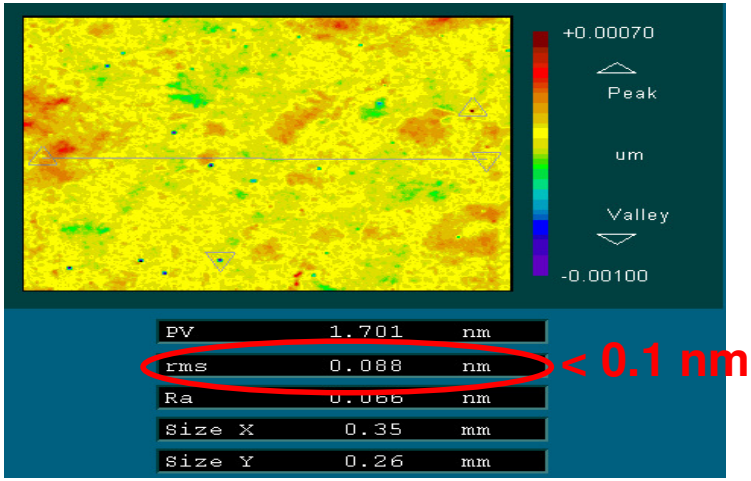
CVD diamond window, thickness: 100 μm

Interference microscope Zygo NewView 5010

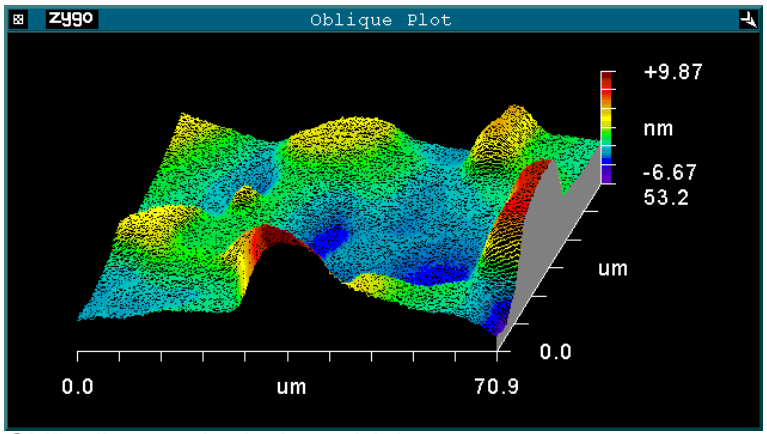


microscope

installed 2001, DEC 2011
upgraded (motorized stage for stitching, new computer, software upgrade)

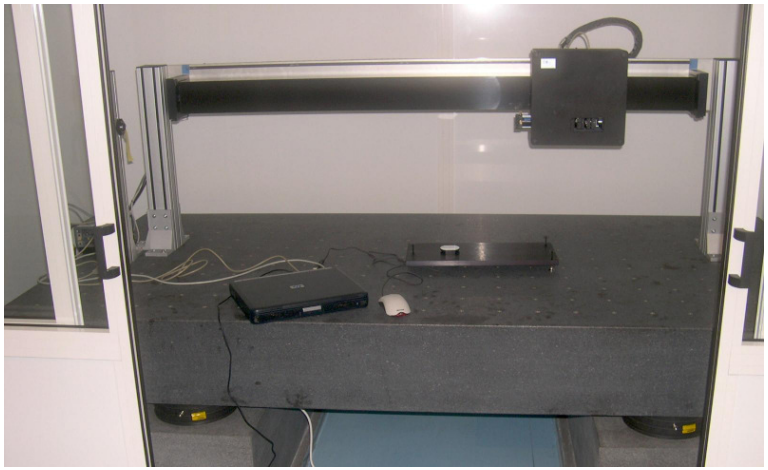


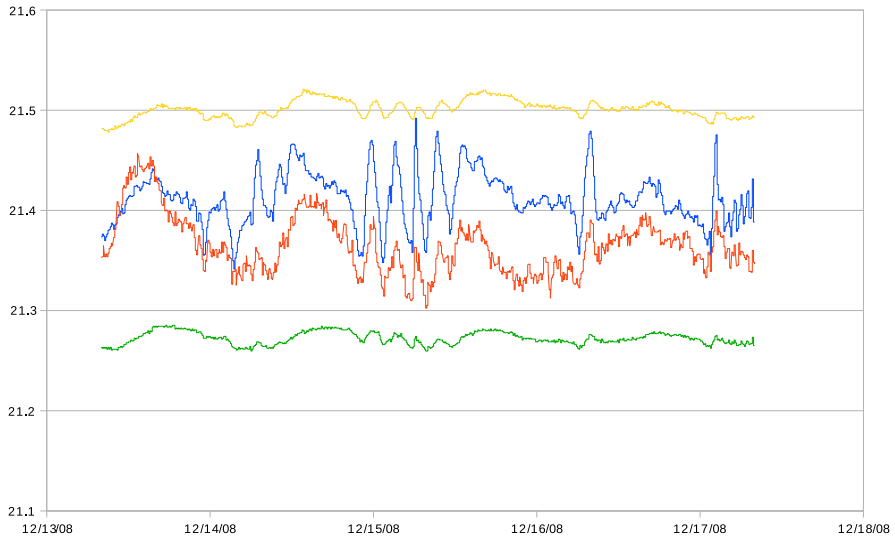
reproducibility



CVD diamond window, thickness: 100 μm

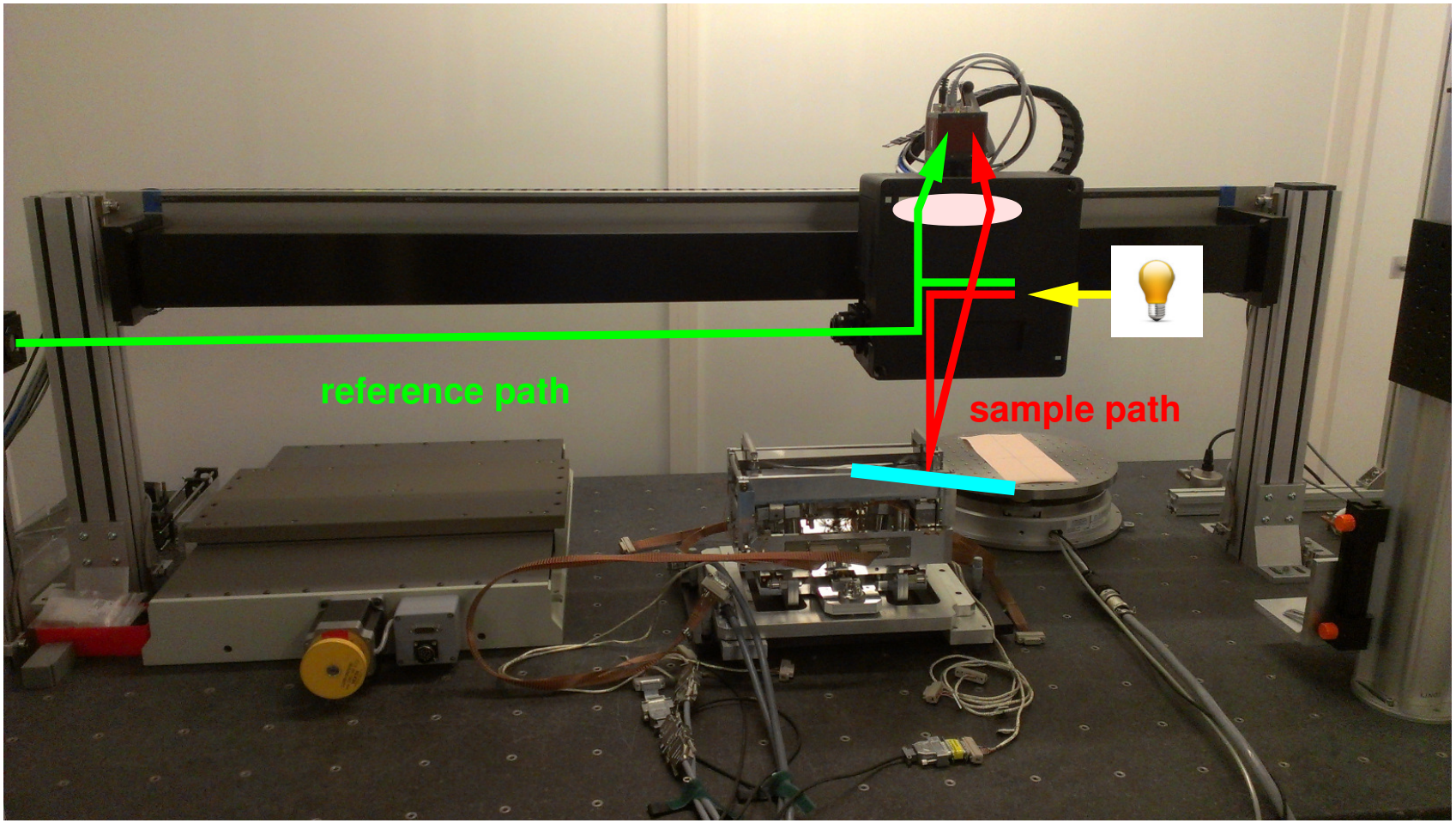
Long Trace Profiler LTP V from Ocean Optics





- optics up to a length of 1.5 m
- shelter with temperature and vibration monitoring
- installed 2005
- delivered with EPICS interface (though never working)

OO LTP V simplified optical principle



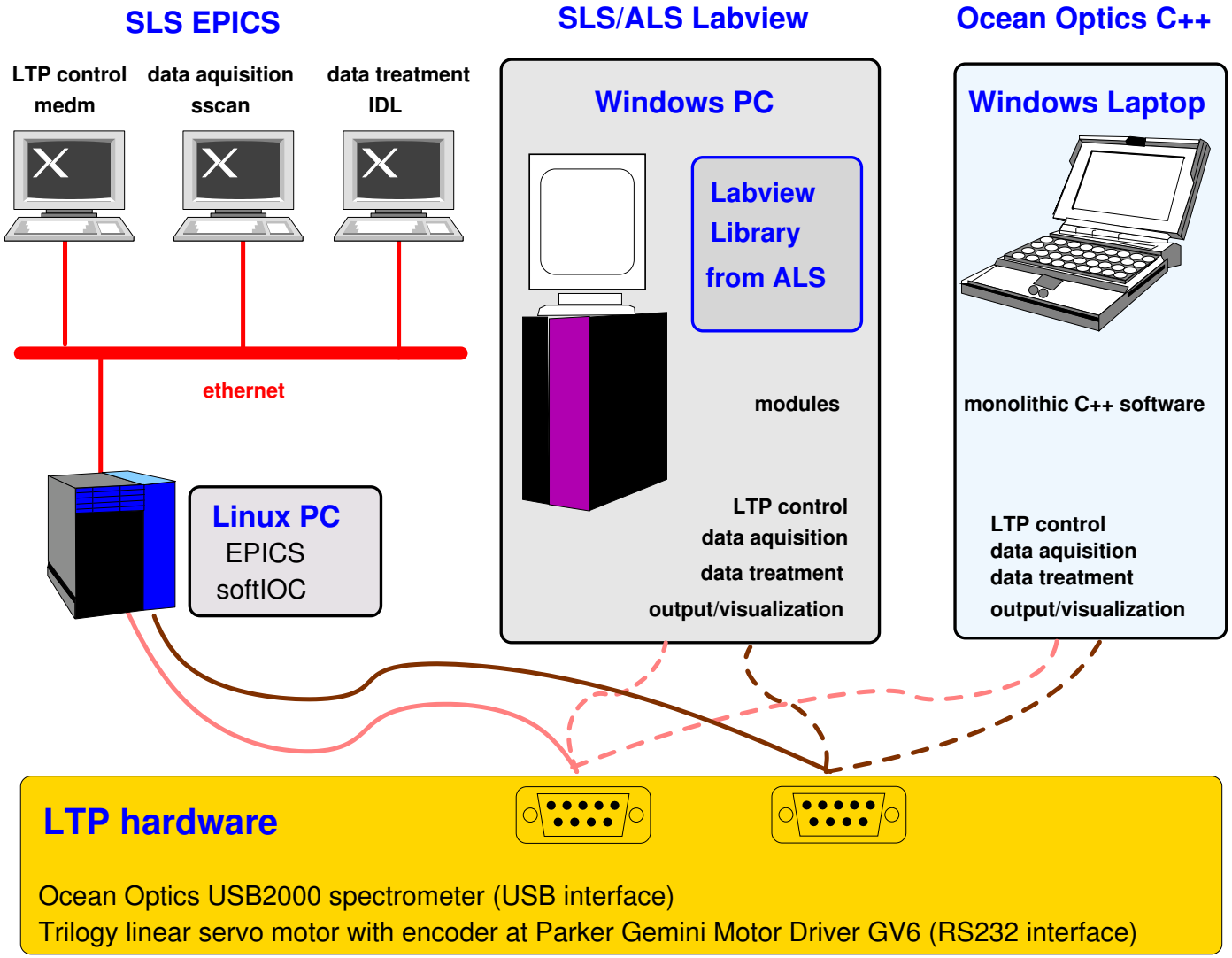
LTP upgrade

motivation: improve accuracy, reliability and (labour) efficiency

- 2009 evaluation of software options (Ocean Optics, LabView, EPICS)
- Nov 2009, LTP optics upgrade, mirrors $\lambda/5$?? $\Longrightarrow$ $\lambda/100$
- Nov 2009, upgrade of LTP controls system to EPICS, 1st step — keeping original 1d- CCD detector from OO
- Jan 2010, 1st usage of new software for KB bender calibration

  details: U. Flechsig, T. Huthwelker, S. Spielmann and J. Krempaskỳ, "LTP-V with EPICS controls system for efficient quality assessment of KB-bender systems", NIMA, 635 (2011) S64, <link to doi>
- Feb 2011, new CCD camera with areaDetector, 1st measurements,
  KB bender calibration, line density measurement of VLS grating
- Dec 2011, additional encoder head for real time position monitoring

Controls Options for OO LTP V @ SLS



New detector for LTP-V (Jan 2011)

areaDetector: Software for 2-D Detectors in EPICS

Mark L. Rivers[a]

[a]*Center for Advanced Radiation Sources and Department of Geophysical Sciences, University of Chicago, Argonne, IL 60439*

Abstract. areaDetector is a new EPICS module designed to support 2-D detectors. It is modular C++ code that greatly simplifies the task of writing support for a new detector. It also supports plugins, which receive detector data from the driver and process it in some way. Existing plugins perform Region-Of-Interest extraction and analysis, file saving (in netCDF, HDF, TIFF and JPEG formats), color conversion, and export to EPICS records for image display in clients like ImageJ and IDL. Drivers have now been written for many of the detectors commonly used at synchrotron beamlines, including CCDs, pixel array and amorphous silicon detectors, and online image plates.

Keywords: Detectors; Software; EPICS; Synchrotron; X-rays; Imaging
PACS: 07.85.Qe, 01.50.hv, 59.-e, 05.Hd, 05.Dz

INTRODUCTION

Many synchrotron beamlines use 2-D detectors, including visible light CCD cameras for imaging, CCD detectors for optical spectroscopy, and x-ray detection using online image plates, CCDs, pixel array detectors and amorphous silicon flat panel detectors. In most cases these detectors need to be controlled from the beamline control system. Many beamlines around the world use the EPICS control system, which is a collaborative open-source control system toolkit. The goals of the areaDetector module are to:

- Minimize the amount of code that needs to be written to implement a new detector.
- Provide a standard interface defining the functions and parameters that a detector driver should support.
- Provide a set of base EPICS records that will be present for every detector using this module. This allows the use of generic EPICS clients for displaying images and controlling cameras and detectors.
- Allow easy extensibility to take advantage of detector-specific features beyond the standard parameters.
- Have high-performance. Applications can be written to get the detector image data through EPICS, but an interface is also available to receive the detector data at a lower-level for very high performance.
- Provide a mechanism for device-independent real-time data analysis such as regions-of-interest and statistics.
- Provide detector drivers for commonly used detectors in synchrotron applications.

ARCHITECTURE

The architecture of the areaDetector module is shown in Fig. 1. From the bottom to the top this architecture consists of the following six layers:

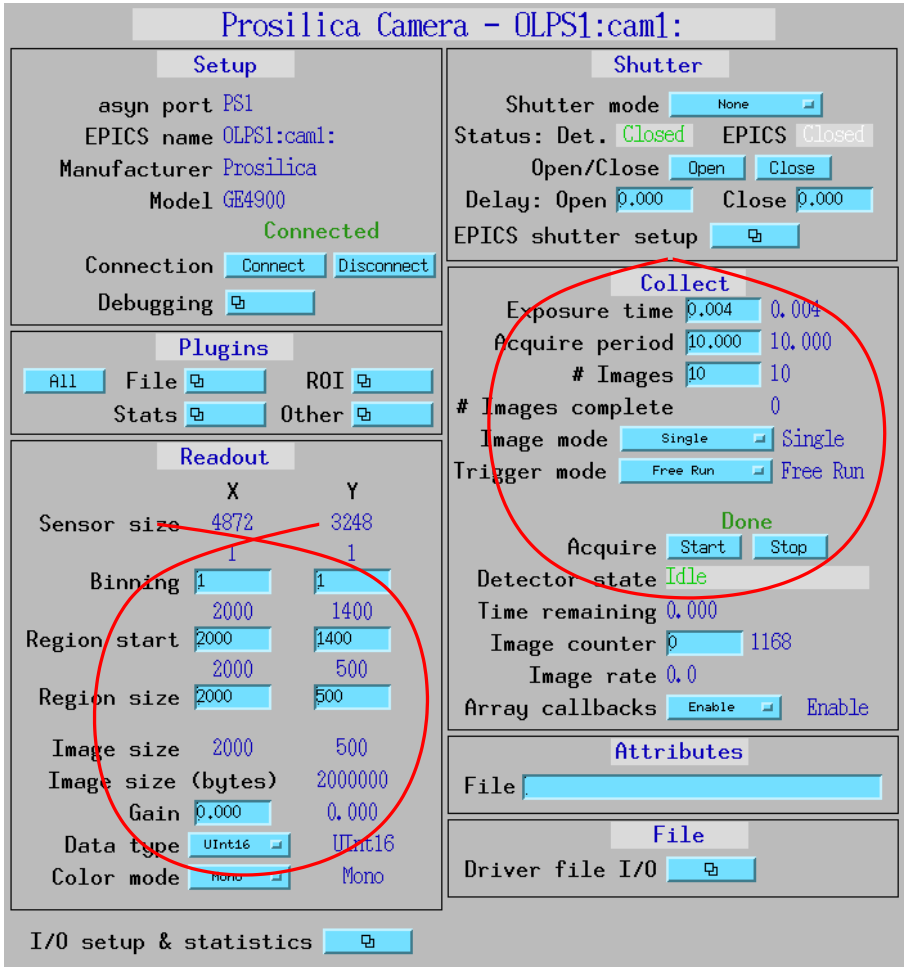
1. This is the layer that allows user written code to communicate with the hardware. It is usually provided by the detector vendor. It may consist of a library or DLL, of a socket protocol to a driver, a Microsoft COM interface, etc.
2. This is the driver that is written for the areaDetector application to control a particular detector. It is written in C++ and inherits from the ADDriver class. It uses the standard asyn interfaces for control and status information. Each time it receives a new data array it can pass it as an NDArray object to all Layer 3 clients that have registered for callbacks. This is the only code that needs to be written to implement a new detector.
3. Code running at this level is called a "plug-in". This code registers with a driver (or another plugin) for a callback whenever there is a new data array. The existing plugins implement file saving (NDPluginFile), region-of-interest

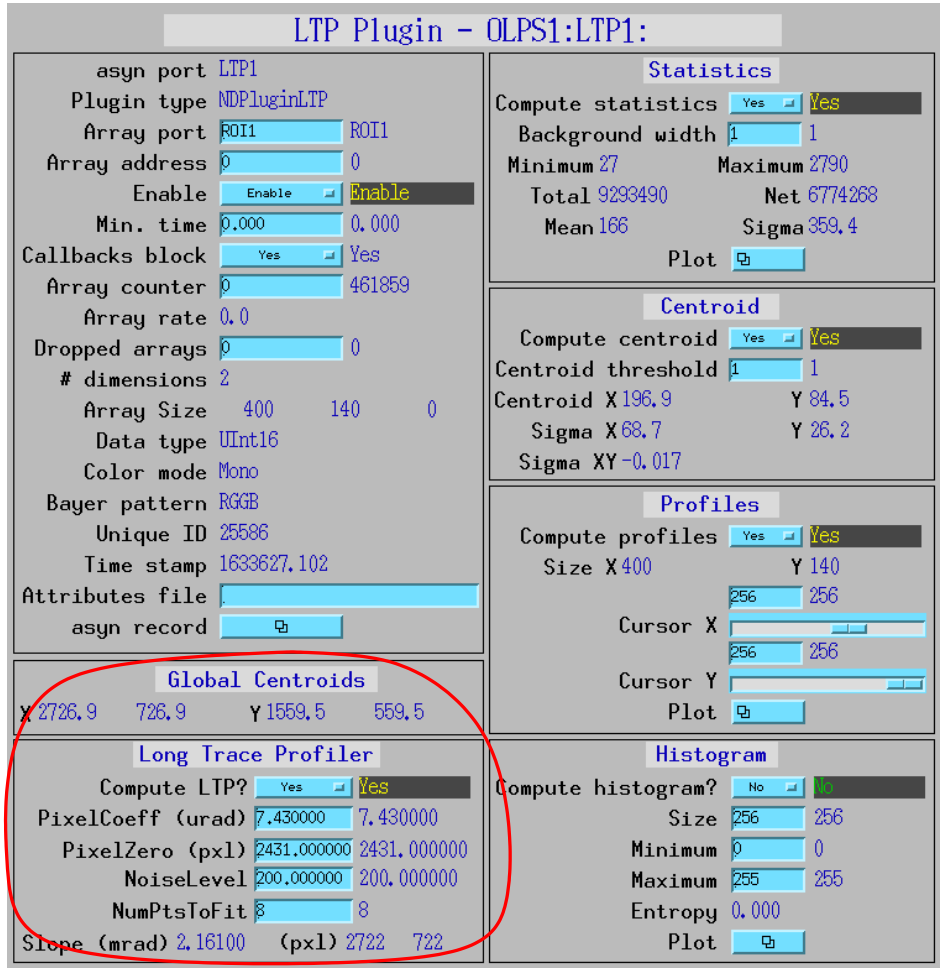
CP1234, *The10th International Conference on Synchrotron Radiation Instrumentation*
R. Garrett, I. Gentle, K. Nugent, and S. Wilkins
© 2010 American Institute of Physics 978-0-7354-0782-4/10$30.00

- PROSILICA 16 Megapixel CCD camera, 12 bit
- Gigabit Ethernet (GigE Vision)
- 4872 x 3248 pixel , pixel size $7.4\ \mu\mathrm{m}$
- 36.1 mm x 24 mm sensor size
- 3.35 fps at full resolution, higher frame rates for ROI's

A driver for areaDetector software is available, and tested!

LTP Plugin for areaDetector





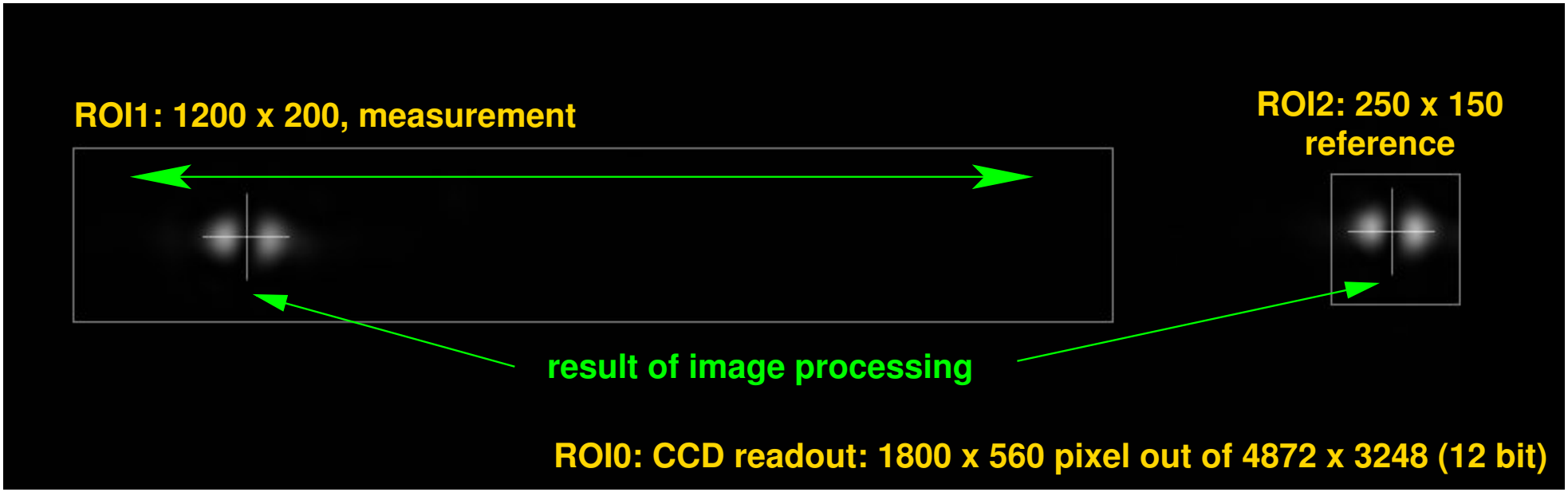
data acquisition with sscan

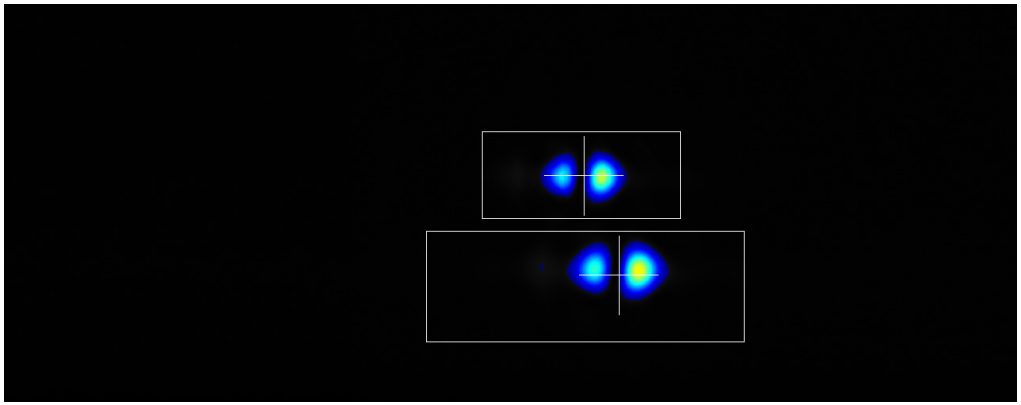
scan of LTP head | scan of bender M1 | scan of bender M2

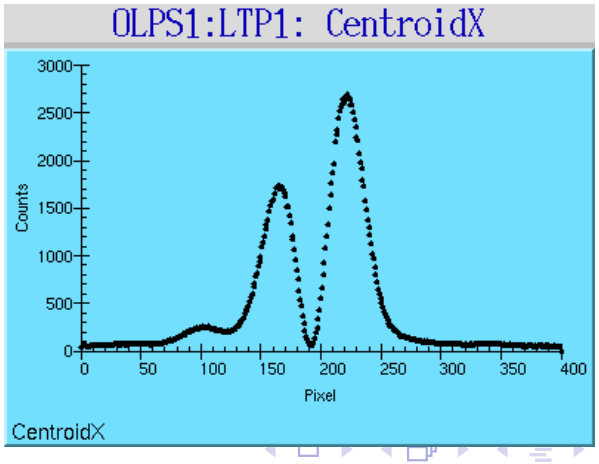
recording of a 3-dimensional data set

LTP plugin for areaDetector in operation

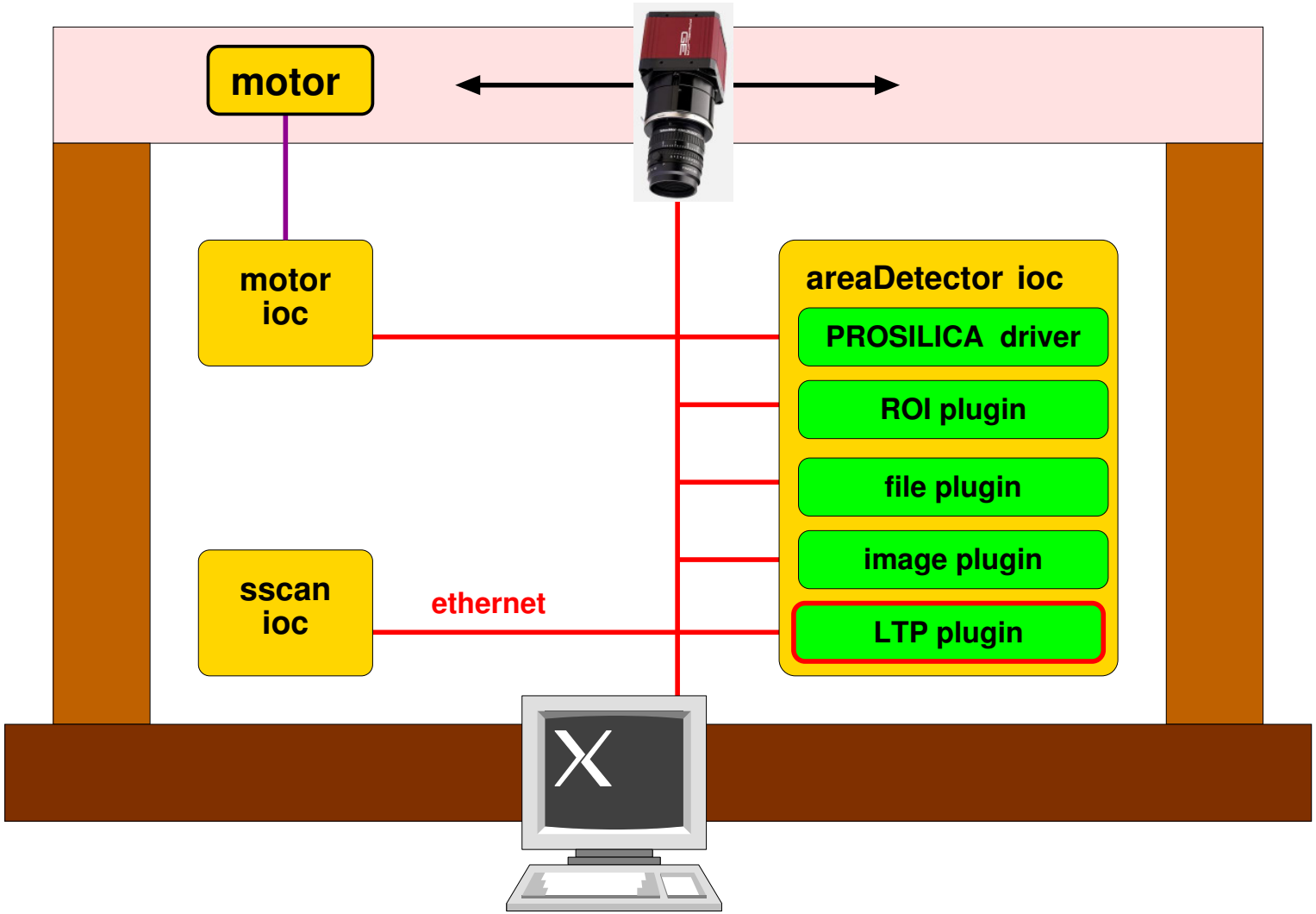
"real time" data processing



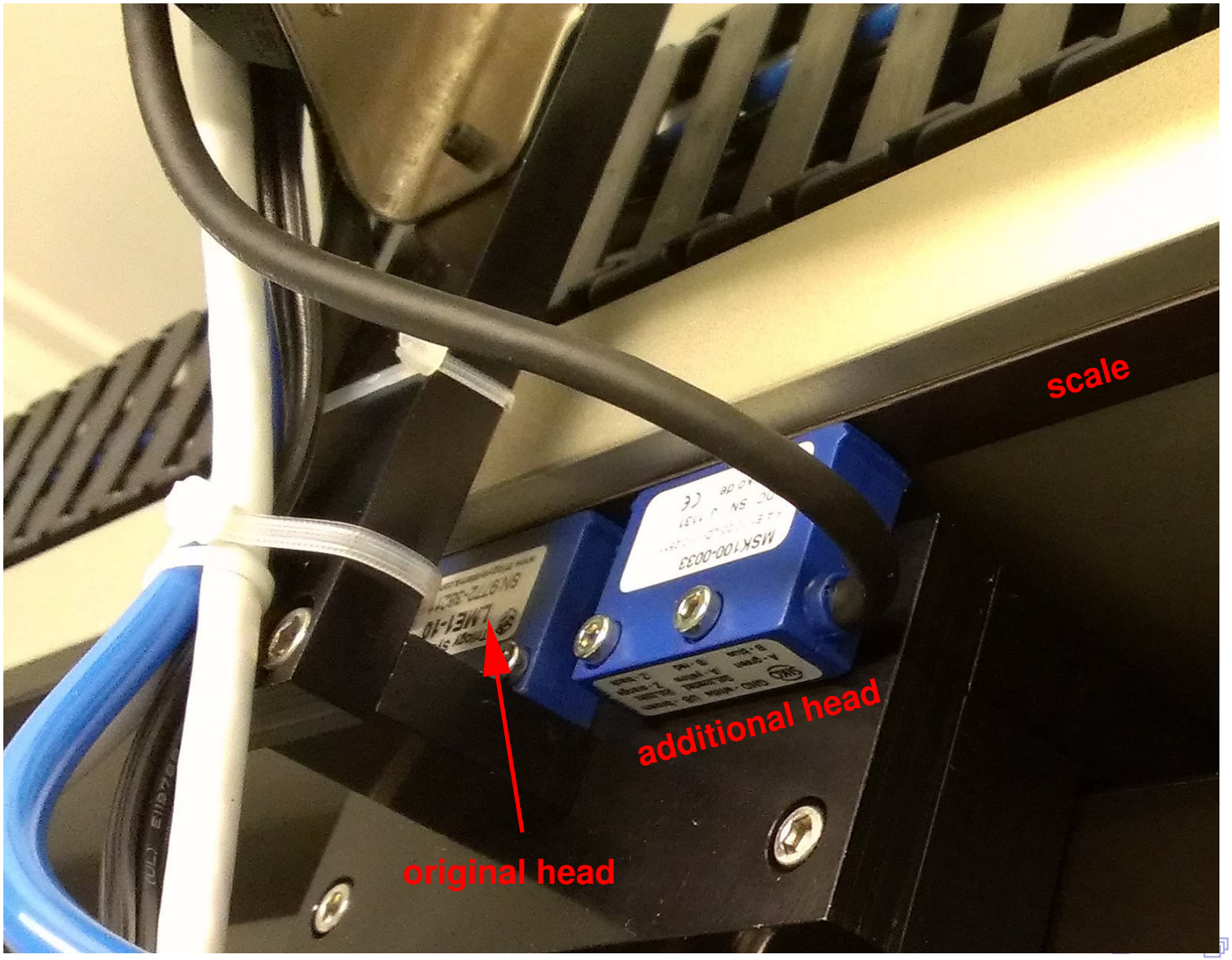




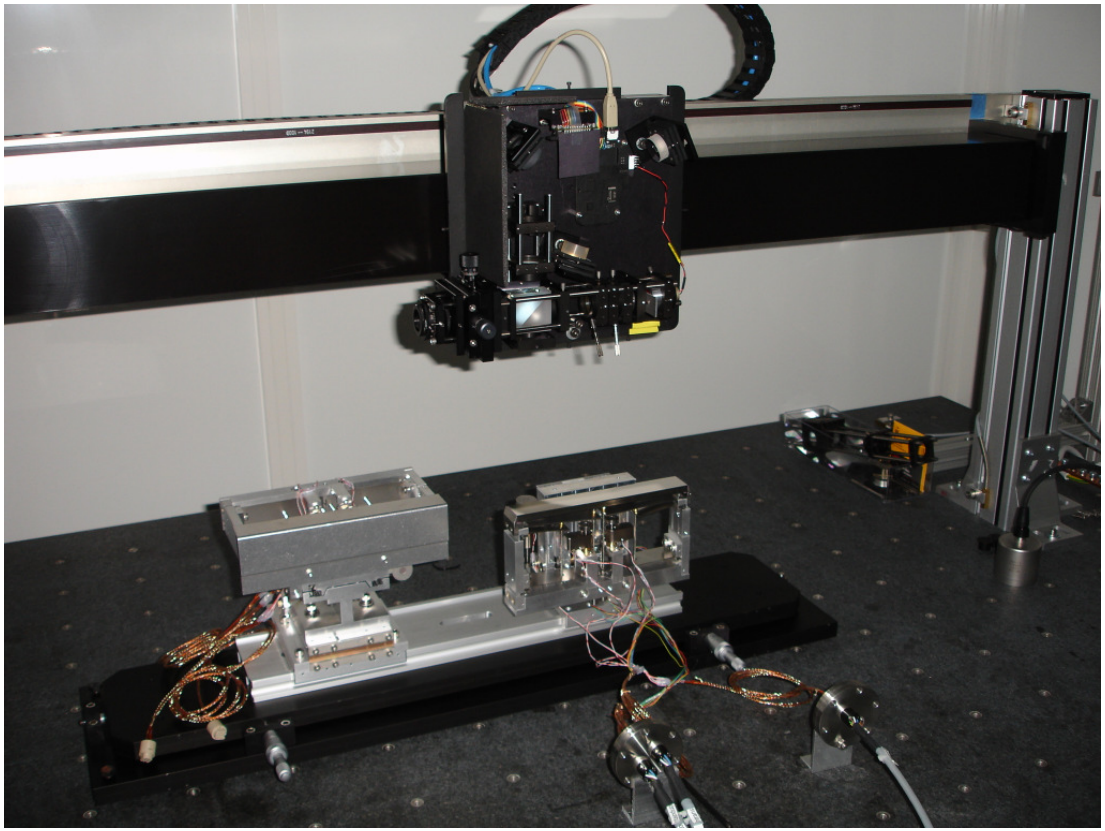
Overview of the new LTP controls scheme



Additional Encoder for real time position monitoring



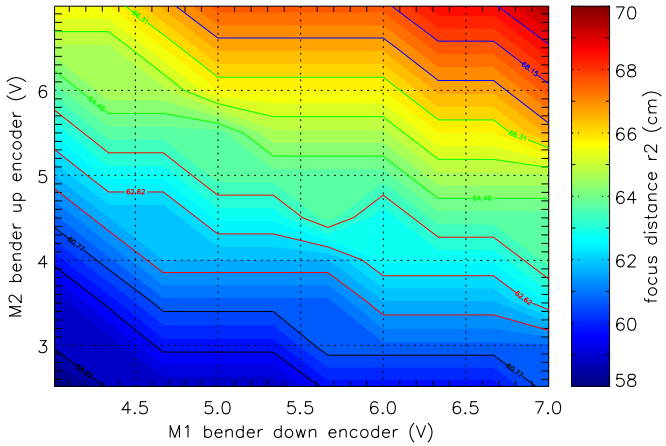
X07MB calibration of KB mirror system



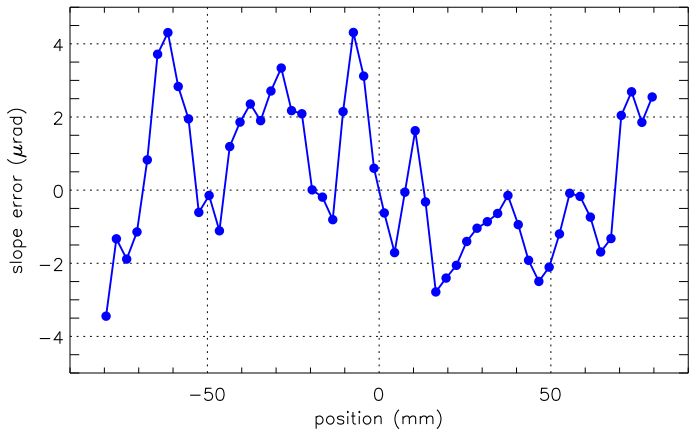
some specs:

- vendor: XRADIA
- demagnification: 39 m : 0.5 m
- length: 20 cm
- type: bender with 2 actuators

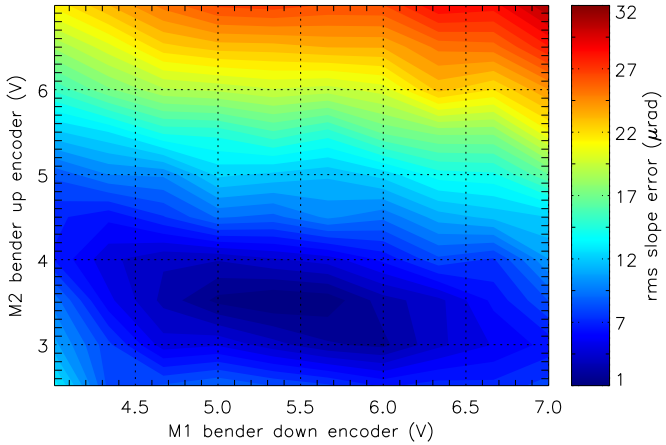
KB bender calibration for X07MB



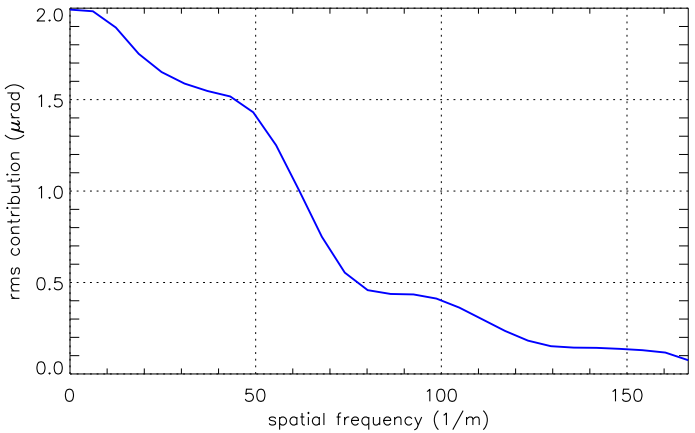
focusing distance



residual slope error at optimum

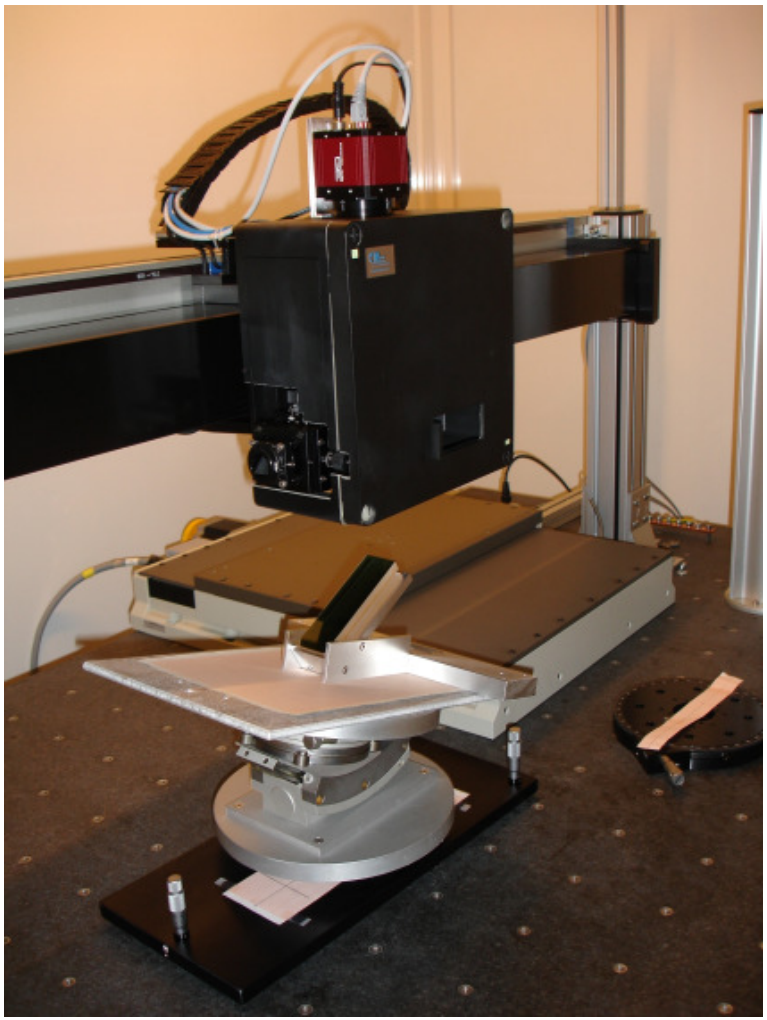


slope results

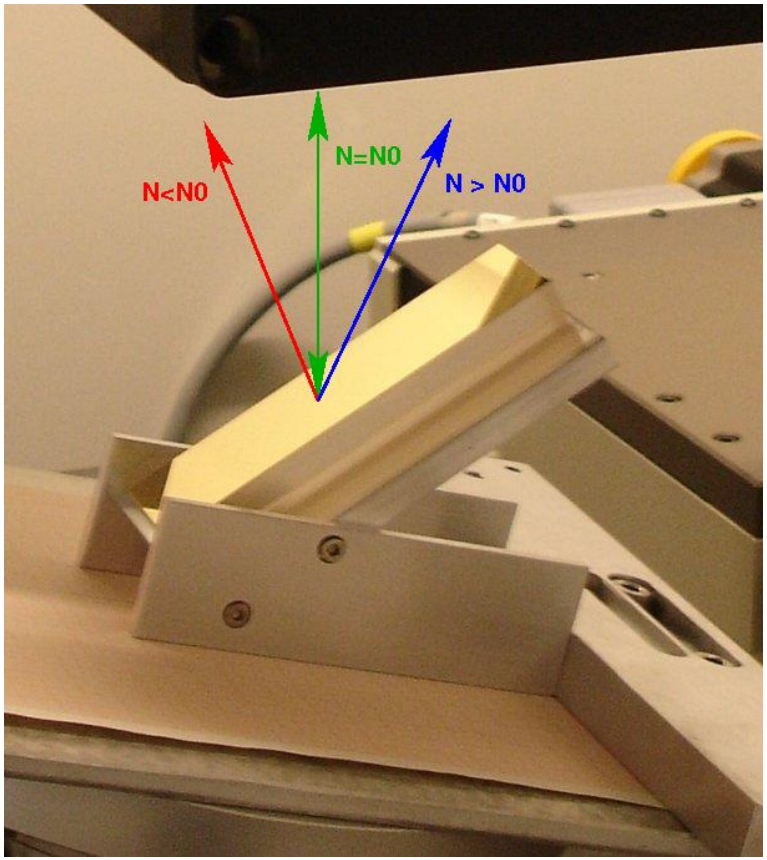


CSD (rms contribution)

VLS Grating, Line Density Measurement

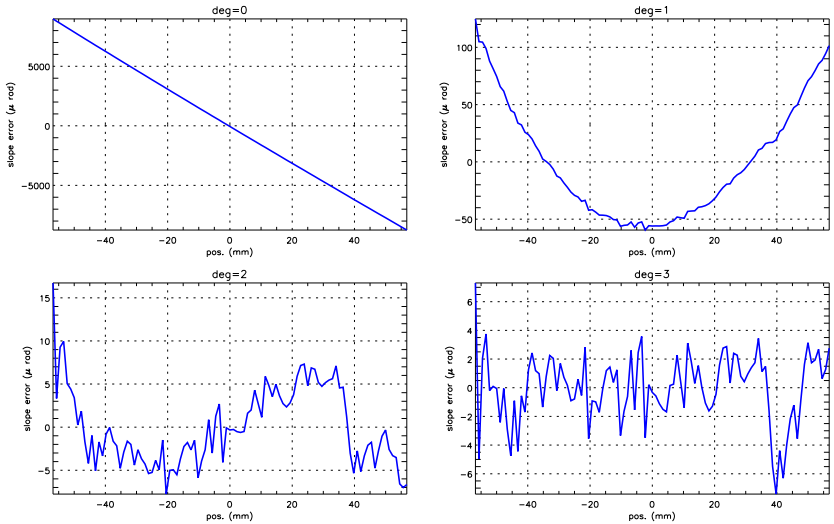


measurement setup

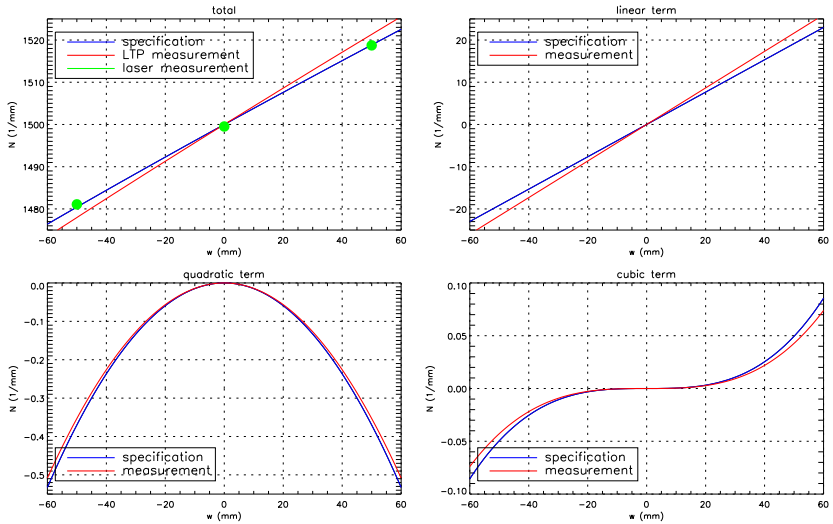


Littrow configuration- principle

VLS Grating, Measurement Results



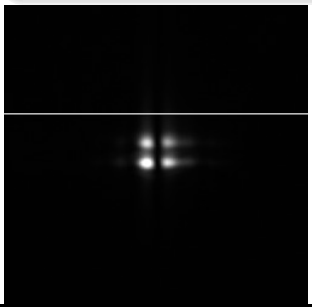
slope results



line density contributions

measured VLS line density

$$N(w) = 1500 + 0.216\,w - 7.06 \times 10^{-5}\,w^2 + 1.71 \times 10^{-7}\,w^3$$



- 1st order diffraction pattern of LTP laser
- **finding:** The diode laser in the LTP head emits two wavelengths $\Delta\lambda \approx 1nm$

Summary

My message

With a moderate upgrade the LTP can stay competitive instrument, advantages are the high spatial resolution ($\approx 1\,\mathrm{mm}$) and high angular range of $> \pm 5\,\mathrm{mrad}$

My message

The SLS approach to control the LTP: EPICS controls system, concentration on the few LTP specific parts and standard tools for all the rest.

Acknowledgments

- metrology labs @ Elettra, BESSY and ESRF (metrology support at the beginning of SLS)
- Peter Takacs, BNL (support to get Ocean Optics code)
- Valeriy Yashchuck, ALS (Labview library)
- Mark Rivers, APS, Univ. of Chicago and EPICS community (areaDetector and other tools)

The End